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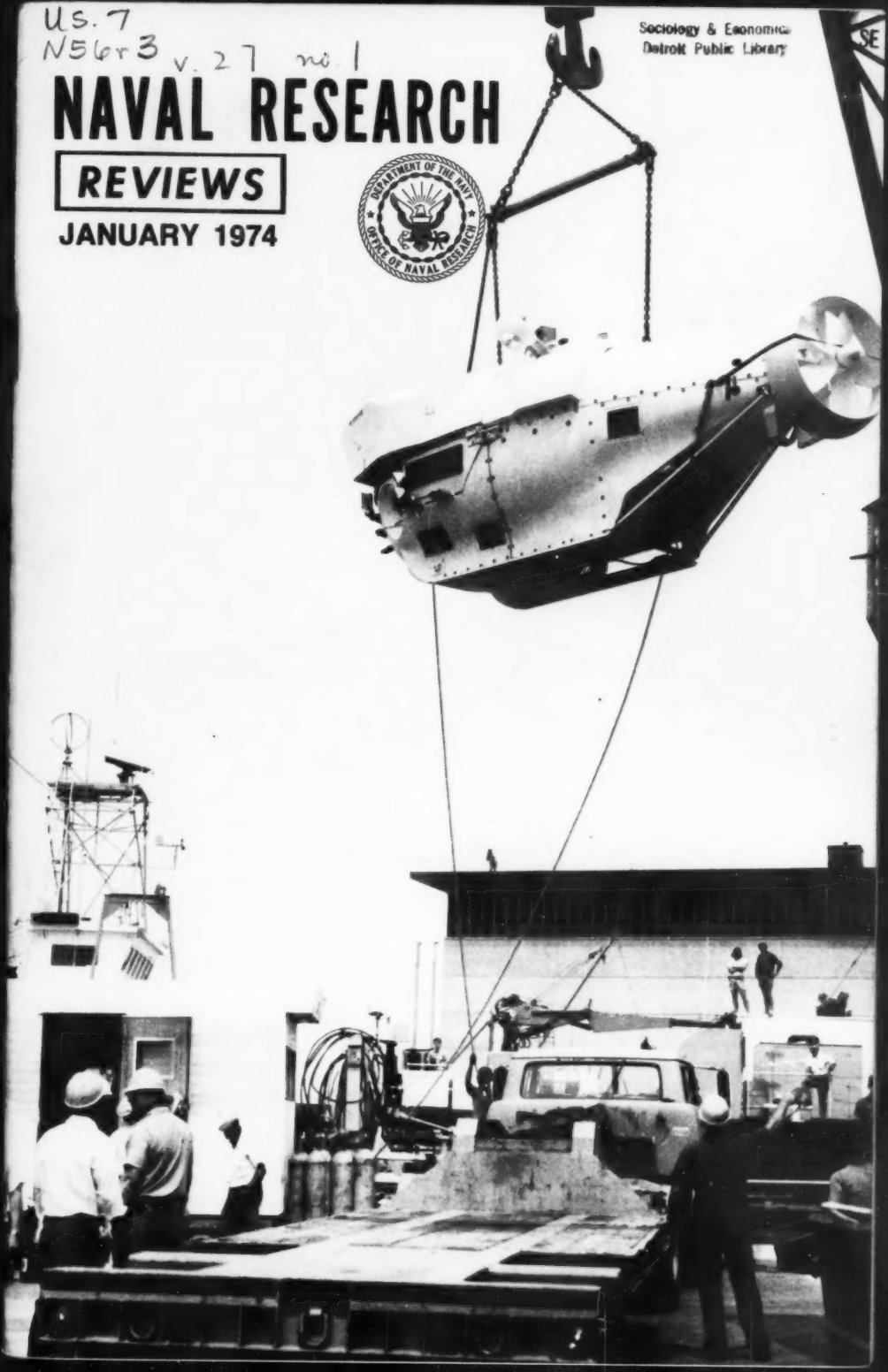
NAVAL RESEARCH

REVIEWS

JANUARY 1974



PROFILES IN SCIENCE

Dr. Leonard Loeb

Dr. Leonard Loeb who is Physics Professor Emeritus at the University of California has been a contractor of the Office of Naval Research for many years. He is recognized as the outstanding theoretician on electrical breakdown in gases. Other fields where his research has made him renown are atomic physics, kinetic theory of gases, static electrification, thunderstorm electricity, physics of lightning, and atmospheric and other gaseous ions.

His book *Fundamental Processes of Electrical Discharge in Gases*, 1939, was the forerunner of his famous *Basic Processes of Gaseous Electronics*, 1955, 1961. This work has been updated by *Recent Advances in Basic Processes of Gaseous Electronics*, which is now being published.

Dr. Loeb, who is a Captain U.S.N.R., is also a member of the Board of Consultants to Director of Navy Laboratories.

The Sanguine Communications System

Forrest L. Dowling*
Office of Naval Research

The Sanguine transmitting facility as envisioned by the U.S. Navy would provide one-way radio communications primarily with submarines cruising at depth nearly anywhere in the world. The system would broadcast from a shore installation in the same manner as a conventional radio transmitter, with two differences which make the communications system unusual; an extremely-low-frequency (ELF) radio wave would be used, and the ground in the vicinity of the station would be part of the antenna array. A test facility constructed near Clam Lake, Wisconsin has been operating and has provided engineering performance data on the system. The purpose and value of submarine communications may be examined in recent discussions on submarine warfare (1,2).

Passive (one-way) communication techniques have been used for centuries to pass along information from headquarters to remote field commanders. Flags, smoke, rockets, solar mirrors, *etc.* limited communications to visual line-of-sight intervals but with the arrival of radio, the transfer of information over great distances became routine. The technique of transmitting from headquarters to remote units which remained mute was used extensively during both world wars not only for ships at sea, but also with aircraft and land forces; the method was even practiced by some early maritime companies who sought to deprive competitors of shipping schedules. The Sanguine system would provide the same function for the U.S. Navy in which submarines would receive information transmitted to them without responding, to preclude a compromise of their presence by being tracked with automatic radio-direction finding apparatus currently used by most military powers.

Until relatively recently, submarines have had to raise their receiving antennas above the sea surface to receive the radio waves. With the advent of very-low-frequency (VLF) techniques submarines were able to receive transmissions when their receiving antennas were positioned just below the surface, but to do this the submarine had to

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be brought closer to the surface where the probability of detection is greatly enhanced. It follows then, that if signals could be received at cruise or station keeping depths the vessel could be kept informed with minimal exposure.

The primary consideration in achieving successful radio reception at the desired depths is that the signals must be of sufficient strength to be able to accurately separate the information from the omnipresent background noise. The strength of the received signal is governed by the radiated power at the transmitter site, by the path of the radio wave to the receiver, and by conditions at the submarine receiver. The required signal-to-noise ratios can be obtained by use of adequate transmitter power and appropriate conditioning of the received noisy signal. The latter is an engineering problem involving electronic filters and special purpose computers to reject major amounts of noise while allowing the desired signal to pass on to the receiver. Optimum antenna and receiver design including modern signal processing techniques is also used to ensure high reliability. These techniques are subject to continuous improvement as advances in technology become available.

Signal Reception

As radio waves propagate through the atmosphere a portion of the electromagnetic energy is refracted downward and, because of the very large contrast in the electrical conductivities of the air and seawater, the angle is essentially vertical towards the earth's center. In its passage through any conducting medium the amplitude of a radiowave will be reduced exponentially to 1/e of its value each time it traverses a distance given by

$$\delta = \sqrt{\frac{2}{\omega\mu\sigma}} \text{ meters} \qquad (1)$$

where: ω = angular frequency
σ = electrical conductivity (4 mhos/meter for sea water)
μ = permeability ($4\pi \times 10^{-7}$ henries/meter)
δ = depth of penetration or skin depth

The frequency of the radio wave then is the only variable by which attenuation can be controlled. Clearly, the lower the frequency the greater the value of δ, hence the less the wave will be attenuated as it passes downwards to the submarine antenna.

Primarily for this reason and other considerations involving characteristics of the ELF wave propagation path, the frequency (f)

probably will be about 75 hertz (cycles per second) which is quite close to the 60 hertz frequency of the standard commercial electrical power system. The value of δ for seawater at 75 hertz is about 29 meters (95 feet), *i.e.* for every 29 meters of seawater through which a radio wave passes it will be attenuated to 37% of its previous level. After penetrating a depth of 150 meters a 75 hertz signal will be only about 0.6% of its value at the sea surface. On the other hand a 20 kilohertz signal would be reduced to 0.6% at only 9 meters depth. It is apparent then that ELF must be used rather than a higher frequency to achieve communications to great depths.

The receiver must have available some minimum signal level to assure the required accuracy in a received message. Three items influence the acceptable minimum: atmospheric noise, electromagnetic noise generated by the submarine, and the electrical noise of the receiving antenna itself. The latter two can be reduced significantly by judicious considerations in the design of the submarine, the internal electrical machinery, and the receiving antenna. Atmospheric noise is a natural phenomenon and cannot be controlled, but because it is generated primarily by lightning its characteristics are understood and they can be exploited in the receiver design to reduce the effects of this type of noise. However, atmospheric noise is attenuated by the same amount as the signal and, because it is signal-to-noise ratio that counts, communications to great depth is possible. Reception actually begins to degrade at the depth where local antenna/receiver noise is equal to atmospheric noise.

The transmitting facility would be much more expensive than the cost of all of the receiving equipment so it is economically important to spend considerable effort in obtaining an optimum receiving system for use aboard submarines. Signal processors, computers and the receiving antenna should enhance the signal to the maximum extent while rejecting the greatest amount of noise. A type of trailing wire antenna would probably be used in which both the electric and the magnetic field components of the radio wave are detected (Figure 1).

Propagation Path

The radio waves leaving the antenna array behave as any other radio frequency emissions, *i.e.* the waves pass from the antenna, propagate through the atmosphere and spread to receiving antennas. The ELF waves are bound between two concentric reflecting shells formed by the earth's surface and the lower part of the ionosphere, a height of about 70 to 80 kilometers. The volume between these

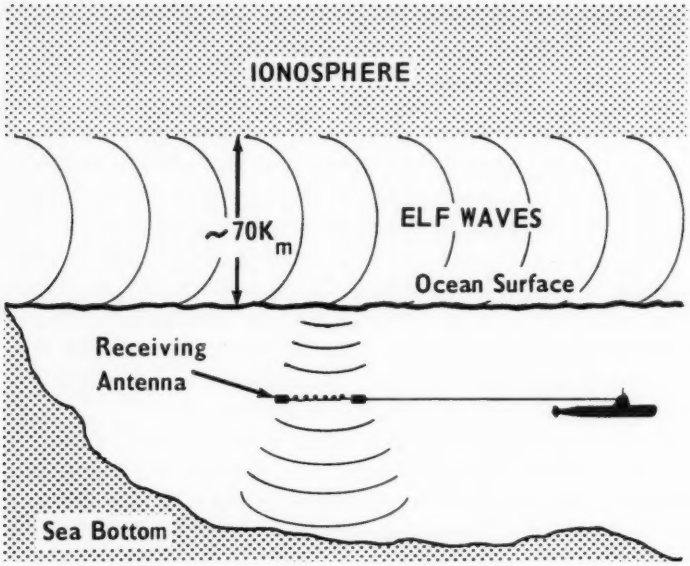

Figure 1 – The receiving antena will probably consist of a type of trailing wire antenna in which both the electric and the magnetic field components are detected.

two surfaces acts as a cavity or wave guide which contains the radio waves.

More than 15 years ago Schumann (3) recognized the importance of this feature as a resonant cavity; energy provided causes the cavity to exhibit resonance or reinforced oscillations at a fundamental frequency of about 8 hertz. The earth-ionosphere cavity resonance has been observed for several years and the characteristics of these oscillations have been intensely studied. Lightning is the principal natural source of energy giving rise to the measured oscillations and because there is virtually a continuous occurrence of lightning somewhere over the earth at all times, the cavity oscillations can be detected anywhere at any time. Many investigators have used these electromagnetic signals to study the nature of the solid earth and the ionosphere.

When the Sanguine transmitter radiates, the cavity will be excited in somewhat the same manner, but at a frequency higher than the fundamental frequency of the cavity. The boundaries of the cavity act to contain the ELF radio signals although some of the energy will leak out through the ionosphere and be lost. The portion which

leaks into the oceans will be available for reception by the submarine antennas.

Transmission System

The signal level required to overcome all of the noise at the submarine receivers has been ascertained; moreover, the rate of attenuation suffered by the radio waves throughout the complete passage from transmitter to receiver has been determined from theoretical and experimental studies. With this data, the magnitude of the radiated energy from the transmitter needed to have acceptable levels of received signals can be resolved. To get this level of radiated power is the crux of Sanguine.

A conventional antenna such as long wires strung above the earth's surface would need to be prohibitively long at ELF frequencies. Distribution of transmitter energy to the antenna would present great problems and line breakages would render part of the system inoperative at times. A wire loop antenna would have the same disadvantages. If, however, the earth itself could be used as part of a loop antenna, an adequate ELF transmitting system would be feasible.

Using the earth as an integral part of a signal transmitting antenna is not a new technique nor is it unique. Geophysicists routinely use grounded dipole antennas as a signal energy source for oil and mineral exploration, and for geophysical studies of the earth's crust and upper mantle. Considerable theoretical and experimental work has been ongoing for several decades because of the many uses of the method. Even communication systems using an earth antenna, either for transmitting or receiving, have been employed in the past. Perhaps the most notable example is that of German technicians during World War I in which electrodes were placed in the earth to detect and monitor electrical signals generated by field telephone lines of the Allied Forces.

Antennas at ELF must be very large to have practical efficiencies (an antenna having 100% efficiency would radiate all of the electrical energy fed to it whereas one with zero efficiency would radiate none). In general the size of the antenna should be on the order of a wavelength of the radiated wave to have high efficiency. The free space wavelength at 75 hertz is 4,000 kilometers (~2,500 miles); therefore, a long wire antenna of a workable length (say 50 miles) would be only a very small fraction of a wavelength and its efficiency would be correspondingly small.

Feeder lines transfer the electrical energy from a transmitter to a wire antenna in conventional systems but with the Sanguine transmitter the feeder lines will be connected to two separated grounded

electrodes in the earth and the energy will flow between them *via* multiple paths within the earth (Figure 2). These current paths are analogous to magnetic field lines as illustrated by sprinkling iron filings on a sheet of paper resting on a permanent magnet; however, the current paths in the earth are 3-dimensional and occupy the volume beneath the earth's surface containing the electrodes. The portion of total current taking a particular path is governed by the electrical resistivity (opposition to the current) of the rocks along the path, such that the smaller the resistivity, the greater the current. The resulting electromagnetic field strength of a single current path is proportional not only to the amount of current but also to the area enclosed by the path.

The area enclosed can be made large by placing the electrodes in a region having highly resistive rock extending to great depths. Because the opposition to current is large there will be multiple (parallel)

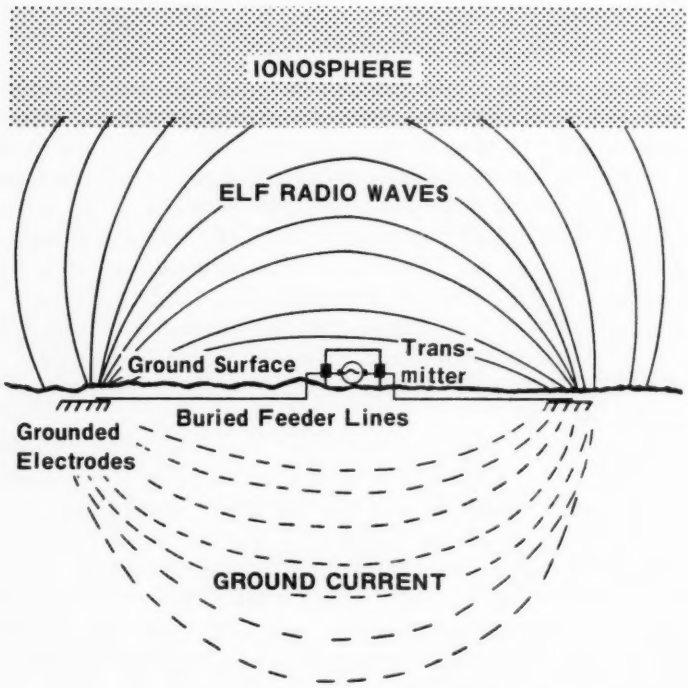

Figure 2 – The Sanguine transmitter will have feeder lines connected to two separated and grounded electrodes in the earth and the energy will flow between them via multiple paths within the earth.

current paths extending to great depths by which the total impedance to the current is minimized. The net effect is large areas enclosed by current paths resulting in higher field strengths than for areas having less resistive rocks. Increased separation of the grounded electrodes also results in the current having deeper paths.

A ground-antenna system with electrodes widely separated in highly resistive rock acts as a large multi-turn loop antenna whose electrical size is much greater than the distance between the electrodes; the area of an equivalent loop antenna is,

$$\text{Area} = L\left(\frac{\delta}{\sqrt{2}}\right) \qquad (2)$$

where L = the distance between electrodes and δ is given by (1). As with any conventional antenna the resulting electromagnetic fields can be increased and steered in preferred directions by combining several individual antennas together to form an array. The Sanguine system would consist of several individual ground antennas coupled such that the array would produce the required radiation pattern.

Environmental Considerations

The Sanguine antenna system is designed to have a total radiated power in the hundreds of watts which is on the order of a tenth of one percent of that of a single large commercial AM broadcast station. A large area would be encompassed by the Sanguine antenna array over which relatively low power would be radiated. The resulting electric and magnetic fields can be compared to those encountered in a single dwelling house.

Electric field strengths of about 0.07 volts/meter will be present in the ground immediately above the buried feeder lines of the Sanguine antenna and decreases as one moves away from the area. This is about the same as the average value measured near home 60 hertz electric power system ground rods (0.014 to 0.52 volts/meter with an average of 0.09 volts/meter). Electric field strengths near commercial radio and television transmitting antennas are orders of magnitude larger than the maximum Sanguine levels.

The magnetic field over the buried feeder lines will be about 0.13 gauss. In contrast, electric hairdryers, electric shavers and electric blankets (to name just three items which produced localized but large magnetic fields in the home) measure from 5 to 25 gauss, two orders of magnitude greater than the maximum Sanguine levels.

Since their inception the flora and fauna of the world most probably have been exposed to natural electric and magnetic fields, and certainly those of industrialized countries by man-made fields for many decades. These ubiquitous fields result from such intentional transmissions as radio, radar, roentgenography, *etc.* to inadvertent radiation from electrical power lines, electric machinery and home appliances.

The possible side effects of long-term exposure to low levels of electric and magnetic fields have not been systematically investigated in the past; research efforts have dealt with specific interests usually at high power-density levels and with much higher frequencies. Interest in environmental considerations of the Sanguine transmitter has provided a vehicle for rather comprehensive studies of the effects of low level electromagnetic emissions on plant and animal life. The Office of Naval Research through its Physiology Programs (Code 441) has been supporting research directed at studying the perception and/or possible harmful side effects of ELF electromagnetic fields by and to representative animals. Field studies on isolated ecological systems have also been undertaken (4,5).

Readers interested in further technical aspects of the Sanguine system are referred to three publications which give considerable theoretical detail and empirical results (6, 7, 8). A study by the National Academy of Sciences on the feasibility of the Sanguine system resulted in a report in which NAS concluded that the system would work essentially as designed (9).

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NSRDC and the New ALVIN

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Naval Ship Research and Development Center

Recently, the Navy announced that the Deep Submergence Research Vehicle, ALVIN, owned by the Office of Naval Research and operated by the Woods Hole Oceanographic Institution, had successfully completed three test dives equivalent to a depth of 12,000 feet. The dives, two of which were unmanned and the third manned by a crew of three, were standard Navy tests conducted in the Ocean Environment Simulation Facility at the Naval Ship Research and Development Center, Annapolis, to certify ALVIN for Project FAMOUS, the French-American Mid-Ocean Undersea Study which began this summer and is expected to continue through 1974.

The deep-diving vehicle has been assigned to perform close-range studies and to map the Mid-Atlantic Ridge rift valley which lies nearly 200 miles south of the Azores. The Ridge, with an average depth of 7200 feet and a maximum depth of approximately 12,000 feet, is part of a colossal undersea mountain range beginning in the Arctic Ocean and extending the length of the Atlantic, around Africa, through the Indian Ocean to the Pacific.

Initially, the ALVIN was equipped with a seven-foot-diameter pressure hull fabricated of 1.33-inch-thick, high-strength steel, which was designed for an operating depth capability to 6000 feet. But to conduct the mission required by Project FAMOUS, extensive modifications to the vehicle's hull, systems, and subsystems were needed to double its operating depth capability.

These requirements presented challenges, the first of which was to provide a hull material that could withstand pressures at a depth of 12,000 feet with no increase in the weight of the vehicle. Also new systems and subsystems were needed.

Changes made to the ALVIN called for design and structural reevaluation so that the vehicle could meet the safety standards.

Project TITANES

Faced with these criteria, the Navy turned to its R&D laboratories for the expertise needed to surmount the challenges. In 1969, the

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Naval engineering establishment and the Woods Hole Oceanographic Institution organized Project TITANES to increase the operational depth of the ALVIN as well as to increase its payload capability.

The Naval Ship Research and Development Center, having already developed technological expertise in titanium and its alloys, proposed to replace the ALVIN's steel hull with one made of titanium. The high strength-to-weight ratio of this material made it attractive. It was determined that the thickness of the hull could be increased and the weight decreased, thus allowing for a greater payload.

It was necessary to evaluate the syntactic foam buoyancy material in the original ALVIN to determine the degree of service degradation, and to ascertain whether the foam was suitable for use at depths down to 12,000 feet.

The Structures Department at the Center's Carderock Laboratory was directed to provide consulting services for detailed design and technical information for a comprehensive fabrication design package. They were also required to prepare procedures for acceptance tests, including creep testing of the titanium sphere before its installation in the ALVIN.

The Naval Research Laboratory assisted the Center by providing special fracture-toughness tests of the base material, weld metal, and hull penetrator material. The Mare Island Naval Shipyard, Vallejo, California, was assigned the task of fabricating the titanium spheres.

New systems and subsystems were developed for installation in the ALVIN. And, the completion of the Center's portion of the project was to hydrostatically pressurize the rebuilt vehicle in the Ocean Environment Simulation Facility at the Annapolis Laboratory.

With these guide lines laid down, the decision was made to construct two identical titanium alloy pressure hulls, one for installation in the ALVIN; the second to be tested to gain experience in fabricating thick-section titanium structures, to provide information on the performance of titanium in the deep-ocean environment, and to verify Navy design techniques for the material.

The rebuilding of the original ALVIN began.

The Materials Department

In February 1969, the Materials Department published "Fabrication, Welding and Inspection of Ti-621/0.8 Mo Alloy Titanium 'ALVIN/AUTEC' Submersible Hulls" which was to guide Mare Island in constructing the titanium pressure spheres. This document, one of the first fabrication guides to utilize rational fracture-toughness criteria in establishing permitted and prohibited flaw levels in struc-

tures, was based on laboratory-developed techniques for forming, forging, welding and inspecting heavy-section alloy titanium structures. (Figure 1)

Included in the publication was information on advanced capabilities for forming large, seven-foot-diameter, three-inch-thick, single piece hemispheres; forging six-inch-thick hull inserts for hatch and viewports; forming heavy-section torsion springs; close-tolerance machining of hulls and hardware; production-shop, hot-wire, gas-tungsten-arc welding; and all-position stud welding. Quality assurance procedures for each step were written into the document through the establishment of non-destructive and mechanical property evaluation techniques for formed plate material, forgings and welds. (Figure 2)

Material specifications were prepared to procure hull material and welding wire. Department personnel monitored production of these items as well as the forging of hull inserts, and the manufacture of the first circularly-rolled titanium plates. (Figure 3)

The Department directed the press-forming of the thick-walled hemispheres for the pressure hulls, and the cleaning and spooling of welding wire prior to its delivery to Mare Island. Material from hemispheres and insert dropouts was evaluated to certify the mechanical properties of the formed hulls.

Throughout these operations, the Materials Department served as consultant to Mare Island in solving production problems, particularly in the areas of stud welding, spring forming, and machining of titanium alloy.

Evaluation of samples selected from the 6200 pounds of syntactic foam initially surrounding the ALVIN's pressure hull showed negligible in-service deterioration. However, when the foam was subjected to hydrostatic compressive strength testing at 5350 pounds per square inch, equivalent to pressures at a depth of 12,000 feet, Materials engineers recommended replacing approximately 80% of the foam with a buoyancy material having greater strength.

In 1969, the Mare Island Naval Shipyard began its part of Project TITANES. Fabrication and assembly of the spheres took place under continual supervision of Center personnel both at Annapolis and at Mare Island.

The Structures Department

The hull and components for the ALVIN were designed by this Department. Engineers assisted in selecting the operating depth, hull thickness and fabrication tolerances of the vehicle. They determined

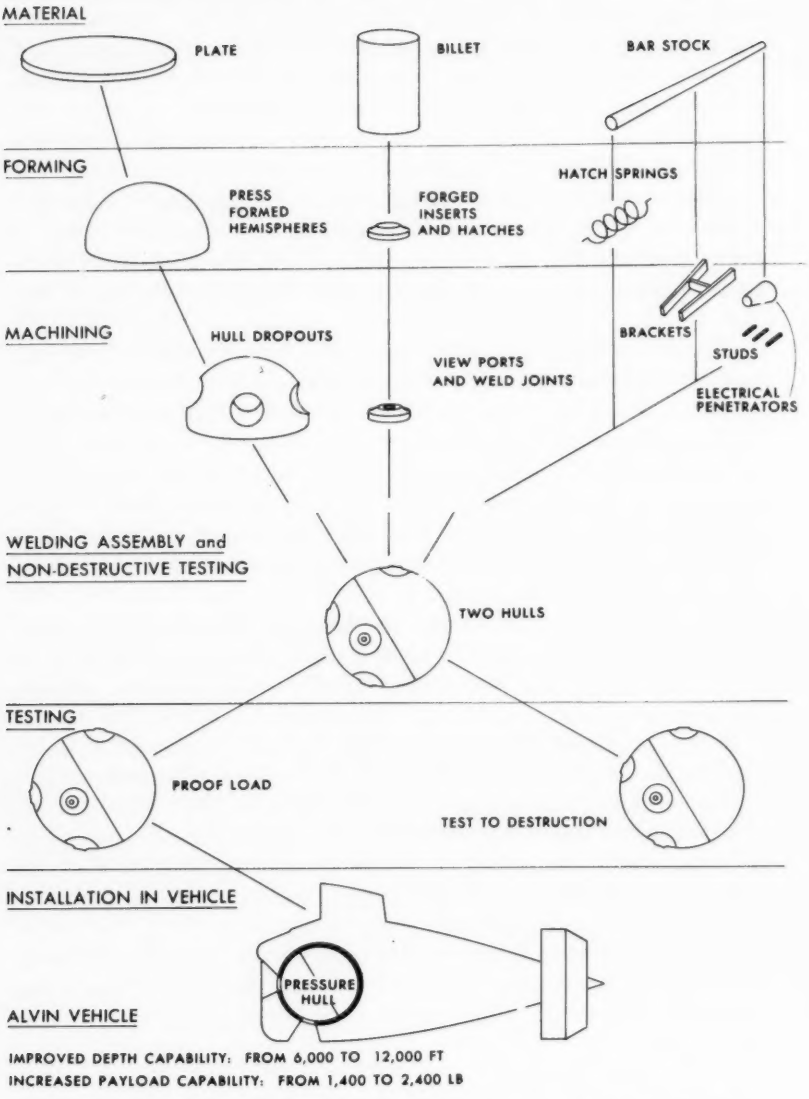

Figure 1 – Steps in fabricating titanium pressure hull for DSRV ALVIN.

Figure 2 – Window, hatch, and hatch cover forgings.

Figure 3 – Circular rolling of Ti 621/0.8 Mo alloy titanium plate.

the approach for proof-testing the completed spheres which would establish the operating depth capabilities of the completed vehicle.

Four years later, in January 1973, the first prototype sphere was delivered to the Naval Ship Research and Development Center to undergo a series of acceptance tests.

Under the direction of Structures Department engineers, the location of flat spots or critical areas in the prototype sphere were determined and the sphere was instrumented with strain gauges. Strain gauges were also placed in areas of other structural details. Hatch deflection gauges were installed and hull acoustic emissions were monitored. (Figure 4)

The hull was placed in a ten-foot, 10,000 psi spherical pressure chamber and subjected to three pressure runs. Data was continuously recorded at varying depths throughout the runs. The final creep test, lasting for 24 hours, recorded success at 10% beyond the planned operating depth of the vehicle. Performance of the sphere verified the structural predictions. Nondestructive inspections indicated that, after test, no flaws were present in the hull. (Figure 5)

When these tests were completed, the sphere was delivered to Woods Hole to be installed on the ALVIN.

The Propulsion and Auxiliary Systems Department

This Department developed systems and subsystems compatible with the rebuilt vehicle. Ocean engineers, together with mechanical

Figure 4 – At Carderock, Structures Department engineers directed the placement of strain gauges on the prototype sphere.

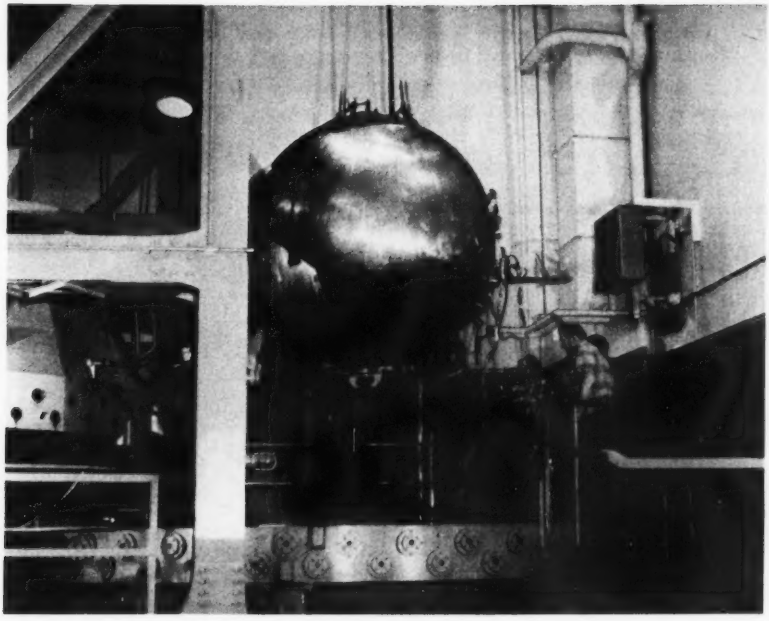

Figure 5 – The hull is lowered into a ten-foot, 10,000 psi spherical pressure chamber and subjected to three pressure runs to verify its structural predictions.

and electrical engineers, developed a seawater variable ballast system which doubled the diving capability of the deep submergence vehicle. (Figure 6)

The heart of the system was a seawater piston-pump driven by an oil-compensated d.c. motor. The pump, capable of operating at 6000 psi in seawater, utilized solid ceramic piston liners and steel pistons coated with a titanium dioxide ceramic to minimize wear when pumping silt-laden water. Titanium was used for all other components which came into direct contact with seawater. The system included a pressure-compensated electric motor with electrical controller and distribution and protection systems. This system was completed and retrofitted on the original ALVIN prior to the installation of the titanium sphere.

Even though each new component had been individually subjected to deep-depth pressure testing before being installed in the ALVIN, Woods Hole requested that the completely rebuilt vehicle undergo a series of simulated dives in the deep submergence pressure chamber at Annapolis to assure total structural and operational integrity.

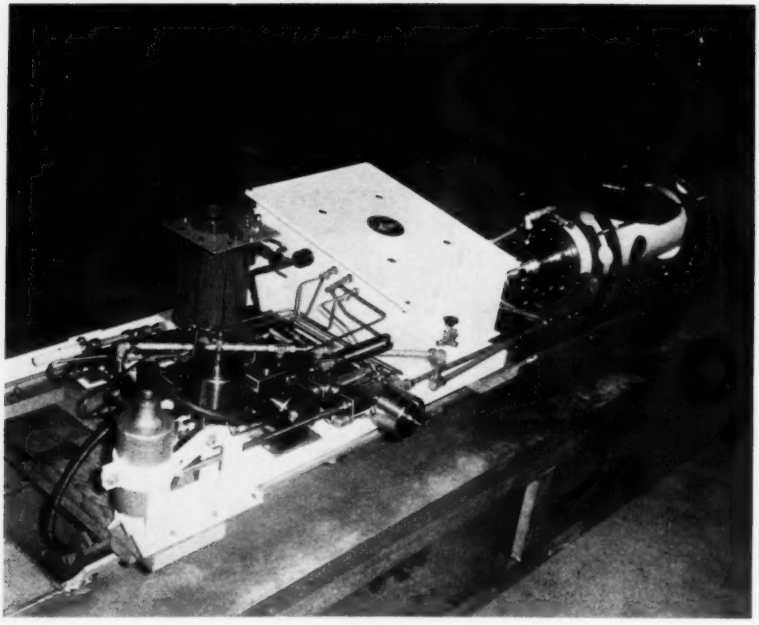

Figure 6 – The Center–developed seawater variable ballast system before installation in the ALVIN. At the left are the seawater control valves. In the center is the pressure-compensated, auxiliary hydraulic control box. To the right is the pressure-compensated seawater pump with its d.c. drive motor and controls.

Late in June 1973, the ALVIN arrived at Annapolis on the mother ship R/V LULU for this purpose. (Figure 7)

The vehicle was transferred to the Ocean Environment Simulation Facility where the crew performed routine servicing procedures before the simulated dives occurred.

Strain gauges, placed throughout the interior of the titanium pressure hull, monitored performance in high stress areas, particularly around the hatch and viewports. Closed-circuit television, installed in the chamber, enabled the engineers to check instrument response during the two unmanned dives. Instrument readouts confirmed that all components were compatible and that the vehicle was in prime operating condition.

The ALVIN's third and final simulated dive was unique in that it was manned by a crew of three, the chief pilot, co-pilot, and an observer from the Naval Ship Systems Command which funded the major portion of the project. (Figure 8)

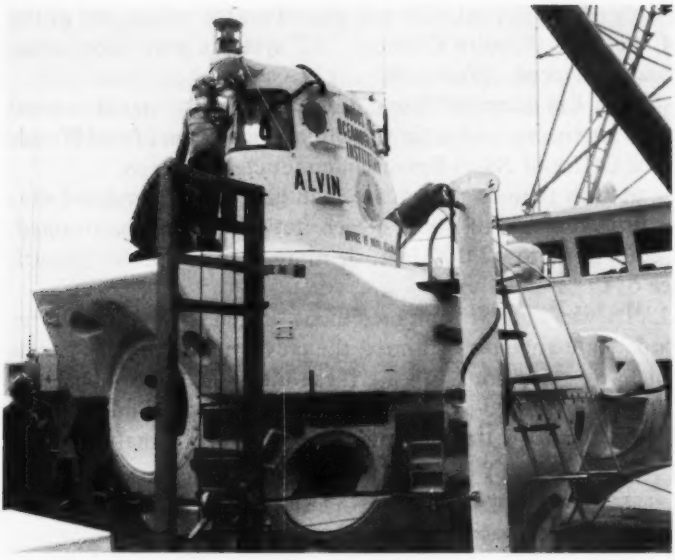

Figure 7 – ALVIN is prepared for lift-off from LULU.

Figure 8 – Chief Pilot Val Wilson, Co-pilot E. L. Bland, Woods Hole Oceanographic Institution, and Lou James, observer from the Naval Ship Systems Command, board the ALVIN for the manned simulated dive.

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On 10 July 1973, the ALVIN was placed on the roll-in sled at the mouth of the large pressure chamber. All systems were thoroughly checked and rechecked. (Figure 9)

In the Ocean Environment Simulation Facility instrument control room, Center engineers, under the direction of personnel from Woods Hole and the Office of Naval Research, conducted the tests.

Starting at zero pounds per square inch gauge, the simulated dive continued in increments of 500 psi each until 5350 psi was attained. This was equivalent to 12,000 feet, or more than two miles beneath the surface of the sea.

The ALVIN was held at each increment for ten to fifteen minutes while Woods Hole engineers scanned the crew and instrument panels in the vehicle by television. During these intervals, instrument data were transmitted by sound-powered telephones from crew members to engineers who recorded the data on charts for future analysis. The

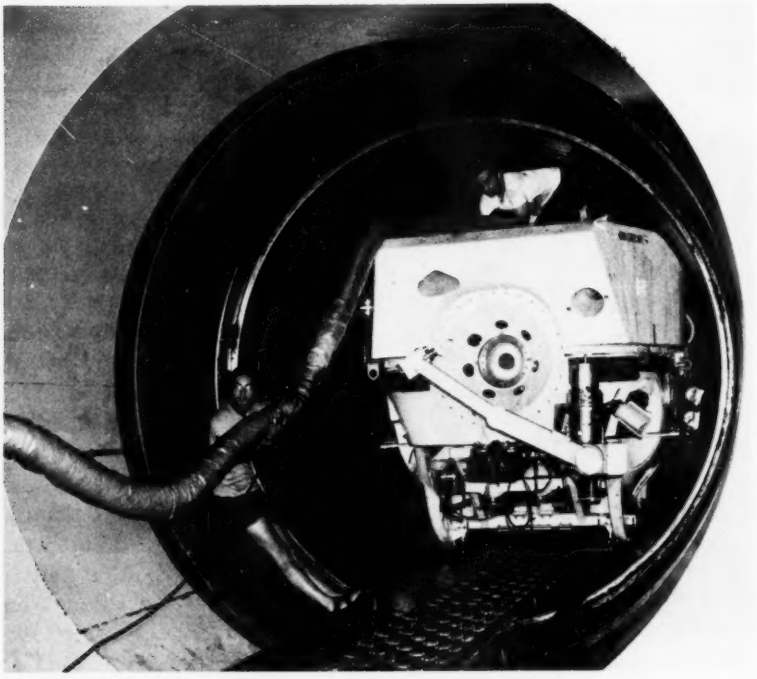

Figure 9 – The ALVIN, positioned in the large pressure tank for the manned test, receives a final air conditioning before the closure plug is inserted.

entire simulated dive covered approximately eight hours, and was a success.

The combined efforts of the Center have enabled the ALVIN to accept the assignment in Project FAMOUS with the assurance that it can fulfill the mission required with competence and safety.

Turbulent Cold Water Mass Found by Sky Lab

Using data gathered by two Skylab crews, an oceanographic phenomenon has been discovered that could open up new fields in weather forecasting, hurricane tracking and fishing.

The phenomenon is a turbulent mass of cold water in the midst of a warm tropical current in the Gulf of Mexico. It was discovered in photos taken last summer by the Skylab 2 crew and reconfirmed by Skylab 3 astronauts Gerald P. Carr, William R. Pogue and Edward G. Gibson during the 21st day of their 84-day mission.

Dr. Robert E. Stevenson of the Office of Naval Research at the Scripps Institution of Oceanography, La Jolla, Calif., said the discovery may change the entire thinking and understanding of thermal energy in the ocean.

The cold water eddy covers a 10- to 30-mile area off the coast of Mexico's Yucatan Peninsula.

Stevenson spotted the eddy when he was studying photos taken by the Skylab 2 crew. He asked the Skylab 3 crew to confirm the cold water mass.

The cold water, an upward surge of chill waters from deep under the surface, apparently is a permanent feature that has never before been recognized. Such surges probably exist in other tropical currents.

Large fields of cold water in the midst of a warm current could cause a massive change in the atmospheric absorption of heat from the ocean.

Calculations of ocean temperatures are critical to weather forecasting. Weather forecasting accuracy could be improved if these eddies are charted.

The eddies bring to the surface rich nutrients from depths of 400 to 500 feet. This, in turn, attracts fish.

By understanding these things, it would permit fishermen to locate fish schools more quickly.

The isolated pockets of cold water also might explain some of the erratic behavior of hurricanes.

On occasion, hurricanes do things we don't understand. The existence of these cold water features has to have implications. Hurricanes survive and grow on heat absorbed from warm water.

The cold water eddy could not be detected by unmanned satellites and probably would never have been found without Skylab. The Skylab 3 astronauts will be asked to search for similar cold water eddies in other warm currents.

On the Naval Research Reserve

NRRC 11-5, San Diego, California Wins National Award

Rear Admiral M. D. Van Orden, USN, Chief of Naval Research, announced that this year's winner of the *A. Hoyt Taylor Award* was NRRC 11-5, San Diego, California. Presentation of the award is planned for early 1974.

The award is given to the company deemed most outstanding from nominations submitted by Commandants of the Continental Naval Districts. The winner, from 59 Research Reserve Units in competition, was selected by a panel composed of the following officers:

CAPT J. E. O'Neil, USNR
Assistant Deputy Director
Director of Naval Reserve
Chief of Naval Operations

CAPT W. D. McClure, USNR
Assistant Chief of Staff for Mobilization
Naval Reserve Personnel Center

CAPT G. A. Heffernan, USN
Director, Operational Applications
Office of Naval Research

Among the notable accomplishments of NRRC 11-5 for Fiscal Year 1973 were the following:

Ready Reserve Status 100%
Satisfactory Federal Year Completion 100%
Drill Attendance 93.3%

Formulation and Printing of "PROJECT DIALOGUE"—A presentation that will present the broad scope of naval research and point out some past and present contributions naval research has made to society as a whole.

Members of the panel commented favorably on the records of the other companies entered in competition. These companies were as follows:

NRRC 1-1	Boston, Massachusetts
NRRC 3-4	Rochester, New York
NRRC 4-1	Princeton, New Jersey

NRRC 5-8	Washington, D. C.
NRRC 6-17	Huntsville, Alabama
NRRC 8-4	Houston, Texas
NRRC 9-6	Minneapolis, Minnesota
NRRC 12-3	Sunnvale, California
NRRC 13-5	Corvallis, Oregon

SOLRAD-HI Launch Set for Spring '75

Scientists and technicians at the Naval Research Laboratory (NRL) are aiming at a March, 1975 launch date for their SOLRAD 11A and 11B satellites, the spaceborne portions of their SOLRAD-HI operational solar monitoring system.

If developments proceed according to plan for the ground terminal and the space vehicles, the two satellites will be launched from the Eastern Test Range, Cape Canaveral, Florida, aboard a single Titan III vehicle into a 69,000 nautical-mile orbit, according to Mr. E. W. Peterkin, Technical Project Manager for the system.

By means of a ground station at Blossom Point, Md. these satellites, backed up by two earlier SOLRAD satellites still in orbit and operating, will furnish 88% continuous real-time monitoring of the sun.

The system will provide data on solar x-rays, ultraviolet rays, particle emissions, celestial x-ray sources and terrestrial auroral and albedo emissions.

The SOLRAD Project was initiated by NRL in 1968 to support the Naval Air Systems Command in the task of developing a means for monitoring solar activity and forecasting solar disturbances that degrade the performance of military systems.

The technical objectives of the project are to provide continuous real-time data on solar emission, expand the data base for solar physics and contribute to an understanding of and predictive capability for solar-terrestrial relationships. The project is being implemented by the combined efforts of NRL Space Science, Space Systems and Engineering Services Division.

The SOLRAD 9 and SOLRAD 10 satellites were constructed at NRL and launched into low-altitude orbits by NASA in March 1968 and July 1971, respectively. X-ray and ultraviolet detectors on board these satellites are providing continuous coverage of solar emission and time-histories of the flaring and nonflaring sun.

Reports of solar x-ray activity are made in near real-time to the Air Force Astrogeophysical Teletype Network when the satellites are in view of the satellite tracking station at Blossom Point, Md. However, the high inclination, low altitude orbits of the current SOLRAD satellites limit the real-time observations to about 12 percent of a day.

Computer plots of continuous solar x-ray levels obtained from satellite memory units are released twice a day by facsimile to the Space Environment Services Center of the National Oceanic and Atmospheric Administration at Boulder, Colo.

Research Notes

Preliminary Field Experiment Slated For North Pacific Research Program

A new oceanographic research program that may eventually lead to the improved long-range prediction of both the ocean environment and the weather around the world will begin its first field experiment in late January, 1974.

Called the North Pacific Experiment (NORPAX), the long-term program is unique in its focus on the changes in the upper waters of the North Pacific Ocean and their interaction with the overlying atmosphere, a process that is believed to influence long-range ocean conditions as well as weather patterns over the entire North American continent.

NORPAX is jointly funded by the Office of Naval Research and the National Science Foundation's International Decade of Ocean Exploration (IDOE) program.

The principal contractor is the Scripps Institution of Oceanography of the University of California, San Diego, with Dr. C. S. Cox of Scripps serving as principal investigator. Also participating in the program are the University of Hawaii, the University of California at Los Angeles, Oregon State University, the University of Alaska, Texas A&M University, the Naval Postgraduate School, Monterey, California; the Navy's Fleet Numerical Weather Center at Monterey; and General Dynamics' Electronics Division, San Diego. Other institutions are expected to join the program as it progresses.

NORPAX is an outgrowth of an earlier Scripps Institution research program supported by the Office of Naval Research and called the North Pacific Study, a program that developed under the guidance of Professor John D. Isaacs of Scripps.

This study was the first attempt to test the theory that both the North Pacific environment and the North American weather are affected by large pools of surface water that are either anomalously warmer or cooler than normal.

The North Pacific Study used primarily great amounts of data collected from merchant ships as well as from deep-moored, 40-foot-diameter, ocean data stations, or "monster" buoys, developed for ONR by General Dynamics, and from a system of smaller, Scripps-developed instrumented buoys.

Some scientists believe that the varying temperature of the pools of surface water can cause variations in the atmosphere which are a key factor in the steering of the jet stream. This high-speed, meandering, aircurrent flows eastward over the middle latitudes of the northern hemisphere. The route it takes appears to determine the temperatures and amount of precipitation experienced by various areas of the continent.

The first indication that the theory has validity came two years ago when Dr. Jerome Namias, then with the National Weather Service and now with Scripps, using data collected by the buoys in the North Pacific Study and from historical files of oceanographic and meteorological data, predicted in the fall of 1971 the

path of the jet stream and what the weather patterns would be for the ensuing winter in the continental United States. It turned out that there was remarkable agreement between his temperature forecasts and the observed temperature distribution.

The equatorial ocean is another important location where interaction with the atmosphere produces long-persistent changes in the weather. Prof. Jakob Bjerknes, of UCLA, has demonstrated that the energy output from the ocean to the atmosphere undergoes large year-to-year changes in this region. Many of the equatorial changes appear to occur almost simultaneously with mid-latitude climate changes. The interconnection is presently not clear to scientists, but it is known that much of the energy that drives the atmosphere throughout the world originates from this equatorial interchange. If NORPAX is able to discover how large-scale and long-persistent patterns of ocean surface conditions in the North Pacific and equatorial waters are controlled by the interaction of sea and air, this knowledge could provide guidance to help achieve world-wide forecasting.

Such forecasts will be important in a number of ways. Large schools of fish are known to desert certain fishing areas when the ocean environment changes sharply. The Navy would not only gain strategic and tactical benefits in planning fleet operations from knowledge of long-term changes of weather, but would also be able to improve the capability of its sonar equipment, since sound propagation is critically affected by the distribution of ocean temperatures near the surface.

A major benefit from prediction of long-range trends in weather, however, comes from the importance of severe storms, floods, droughts, rainy periods, abnormal temperatures and similar events. These environmental vagaries greatly influence the success of crops and winter fuel needs, and are therefore enormously important to man's well being.

Another great benefit would be the establishment of an understanding of the natural range of climatic variation to which man must accommodate and, also, the background of fluctuations against which he must understand the effects of his activities on climate.

NORPAX is attempting only the first of many steps that will be necessary before prediction of long-term trends in weather can be appreciably improved. The emphasis in the NORPAX program is in understanding the complex interaction between sea and air.

Three approaches that NORPAX scientists will pursue in their investigations are:

(1) Documentation of the large-scale changes in the ocean at many places in the Pacific. Under the supervision of Prof. Klaus Wyrtki, of the University of Hawaii, an extensive set of permanent instruments for detecting these changes will be placed on islands in the central and western equatorial Pacific.

(2) Computer studies of oceanic and atmospheric motions will be made to examine some of the ways in which the ocean affects the atmosphere on a large scale, and vice versa.

(3) A direct examination of the sea-to-air heat transfer and the wind-forcing of the sea will be carried out in a series of field experiments.

The first of these field experiments, called POLE, will take place in the North Central Pacific, last for approximately one month, and cover a 200-mile-square area of the ocean.

The measurements will not extend, however, over much of the important areas that ultimately will need study to understand the anomalous air-sea interaction nor will they extend sufficiently long in time. Instead, this first experiment will be largely devoted toward describing the intense wintertime interactions in thorough detail to permit plans for later experiments with large coverage of the ocean. It has been named POLE to highlight the fact that the horizontal sampling will span little more than a point on the overall, total NORPAX scale, whereas the vertical sampling will be reasonably extensive.

The principal instruments and vehicles to be used in POLE are ONR's unique manned Floating Instrument Platform (FLIP), operated by Scripps's Marine Physical Laboratory; a Scripps oceanographic research vessel, *Thomas Washington;* a slightly modified version of the original "monster" buoy, called Alpha; satellites, over-the-horizon radar, a research aircraft provided by the Naval Oceanographic Office, and drifting buoys. Additional data will be derived from merchant ships-of-opportunity using expendable bathythermographs. A tug of the Navy's Third Fleet will be used to tow FLIP, and the *Thomas Washington* will tow the Alpha buoy.

The instruments will provide data on temperature and salinity at the sea surface and below, winds, waves, near-surface currents along with atmospheric temperatures, and humidity. The experiment will mark the first time that such concentrated measurements have been attempted in the winter period when stormy weather produces high wind velocities.

The Alpha buoy will stay on station unattended for one year. It is designed to telemeter its data long distances to a shore station on command, and a Mobile Data Center will be located at the Navy's Fleet Numerical Weather Center, at Monterey, to receive the data.

The recognition of large-scale, air-sea interactions is the outcome of the international scientific examination of phenomena in many ocean areas. The NORPAX program will, therefore, include direct input from an independent Japanese effort, and will eventually involve the work of individual scientists from many nations.

The Navy Environmental Protection Data Base Program

Background

The Secretary of the Navy organized the Environmental Protection Data Base (EPDB) Program to establish a system (a) to determine the effect of naval operations on the environment, (b) to determine Navy compliance with federal, state, and local environmental protection statutes, and (c) to support and evaluate environmental protection and pollution abatement programs.

Naval aviation activities, unlike many other naval activities, generate all types of pollution. Communities near naval aviation activities are affected by emitted waste products from aircraft engines in test cells runs and operationsl flights. This pollution is of relatively large magnitude since there are over 100 naval aviation facilities in the country.

The Naval Air Rework Facility, North Island Naval Air Station, San Diego, California, was chosen as the test site because of its many industrial and operational activities. The program was conducted in the areas of industrial wastes and toxic chemical disposal, air pollution, noise pollution and mathematical modeling. The pilot test phase of the EPDBP has been successfully completed. The project team at North Island has acquired now the expertise needed to plan and initiate pollution identification-data collection programs for naval aviation activities, and to serve as consultants for the design of abatement procedures.

Industrial Wastes

Field surveys determined there were 18 storm sewer outfalls discharging wastes from the North Island Air Station into San Diego Bay and the Pacific Ocean. Many of the sources originated from the industrial rework activities at the station such as aircraft painting and stripping, industrial cleaning, and aircraft washing. Each of these was measured daily and several monitored continuously.

Each industrial test and maintenance operation generating a waste effluent was surveyed to determine the pollution load being discharged. Each contributory operation was described and a flow balance derived between the wastewater entering a specific storm sewer and the wastewater as measured at each sampling point. From this a sampling frequency scheme was derived. Finally the data for each pollutant was analyzed to see if it was within the limits allowed by the regulations.

Recently a new industrial waste treatment facility at North Island became operational. Most of the industrial waste, after treatment, is now discharged to the city of San Diego sanitary sewerage system. Other industrial operations were and are continuing to be relocated to buildings connected to the industrial waste system. The effluent from the treatment plant is tested periodically before being discharged into the municipal sanitary sewerage system to check on compliance with city sewer ordinances.

Air Emissions

A mobile laboratory was used to measure emissions from gas turbine engines at North Island. This laboratory contains two non-dispersive infrared analyzers for measuring carbon monoxide and carbon dioxide, a chemiluminescence analyzer for oxides of nitrogen, a flame ionization detector for the determination of total hydrocarbons, a polarographic analyzer for oxygen and an optical transmissometer for smoke opacity.

The mobile laboratory was used at first to measure emissions and to calculate mass emission factors for several models of the J79 engine (F-4 aircraft) in one of the jet engine test cells at North Island. Later the laboratory participated in engineering tests to evaluate the effect of fuel additives on the performance, emissions and components of a J79 engine. Using additives produced no measurable reduction in gaseous emissions but significant reduction in smoke opacity. Also, the additives were shown to cause undesirable engine deposits.

Noise Measurements

The general nature and extent of noise problems at naval air stations has been assessed by conducting noise impact surveys. Each noise impact survey included a definition of the noise environment due to aircraft and support operations in the vicinity of naval air stations. Also, the survey included information about numbers of aircraft operations, types of aircraft, and flight patterns. Two types of field measurements were performed:

1. Continuous or near continuous wide-band monitoring of noise levels over the time period of the survey at various sites located at each air station.
2. Field measurements of test cells, ground operations, and individual aircraft near major flight paths.

There were several methods proposed for describing the noise impact from airports: the composite noise rating (CNR), the community noise equivalent level (CNEL), and the noise exposure forecast (NEF). Only the NEF system can account for both the duration and pure tone content of each event measured. The CNEL system was recently introduced in California for community noise monitoring purposes. It is based on the A-weighted decibel scale which does not include a frequency distribution of the noise and thus cannot contain a pure-tone correction. Furthermore, the causal agent of a noise event cannot be identified, hence, one cannot distinguish the noise generated by an aircraft from that generated by a car or motorcycle. The NEF system allows this distinction.

The approach chosen for noise data monitoring at North Island contains data from all three methods. This is accomplished by collecting the entire spectrum of a noise event by means of special wide-band tape recording devices. Information unique to each system is then available for comparison, trend development, and modeling.

At thirteen sites on the air station, recordings of all noise activity above a preset threshold were automatically recorded on tape. From the noise contours developed, it was shown that noise from air operations at North Island is well below the 1985 noise limits set by law for airports in the State of California.

Modeling

In order to cut down on the cost of personnel and equipment, it was decided that the use of mathematical models in conjunction with measurements to simulate the generation, movement and levels of pollution would be the best for the North Island project. It was known that a number of such models for aircraft operations were already in existence so that initial modeling efforts would

consist of reviewing these models and applying those that appeared promising. No models for military air operations existed so that some adaptation of the existing models was required. Also the predictions of these models would have to be verified with measurements before they could be used with confidence.

Air Pollution Modeling

The Test Group chose the Gaussian Plume Model for studying air pollution in and around naval air stations. This steady-state, statistical model assumes a normal pollutant concentration distribution for a plume moving in the downwind direction. A level terrain is assumed and no chemical reactions after emission to the air are allowed.

Initial adaptation of the model for use at naval aviation activities has been completed. Computer runs simulating operations at the North Island Naval Air Station/Air Rework Facility complex have been made at the Naval Postgraduate School in Monterey. Output information is in the form of pollutant concentration levels at selected spatial positions in the vicinity of the air station.

Model verification was begun when a mobile trailer equipped for continuous ambient air measurements by Xonics Corporation was purchased by the Naval Civil Engineering Laboratory and stationed at North Island. Background pollutant concentration data has been measured with the trailer for about two to three months. Work is continuing in an effort to more fully validate this model.

Noise modeling

The noise exposure model (NEM-5) developed by the Department of Transportation has been adapted for use at naval air stations and is being applied at North Island Naval Air Station. The model can determine noise levels in terms of any one of several indices, including noise exposure forecast. The model has the capability to handle the complex flight paths that are typical of visual flight operations at military airports. Plotting routines are included in the program to produce noise level contours. When used in conjunction with noise measurement surveys, this model provides accurate noise contours around air stations.

Once accurate noise contours are known for existing flight operations, changes in flight operations will be made in the model in order to minimize the noise exposure on the community.

General Comments

The overall EPDB is well under way but much remains to be done. Measurement methods can be refined and improved. Centralized data recording and analysis needs additional development. Modeling can prove very useful and cost effective and will require additional effort. Finally, the development and design and use of effective abatement procedures must be done as soon as possible. This will assure the public that the Navy is indeed cooperating in the control of the general pollution problem, and is making every effort to meet all federal, state and local pollution standards.

Much more detail concerning the above material is available in the "Final Report–August 1972" of the EPDB project at NAVAIREWORKFAC-NAS-NORIS. This project was titled "Pilot Tests for the Establishment of an Environmental Data Base for Naval Aviation Activities." The report may be obtained by writing

Professor J. H. Duffin
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Monterey, California

The Permafrost Research Institute, Yakutsk, USSR*

Permafrost, a condition where natural materials remain below 0°C for two or more years, is present over some one-fifth of the world's land surface. The largest area of this condition centers in Siberia. Although studied in many locales including Alaska and Canada, it is not surprising to find that much of the research leading to our present knowledge about permafrost has been conducted in the USSR. This goes back to the middle of the last century when A. T. von Middendorff made a study of the characteristics of the frozen ground in a deep shaft which had been sunk 117 m vertically into the permafrost. It was dug as a well; but because permafrost layer is 320 m thick in Yakutsk, no water was reached. This shaft, known as Shakhta Shergina (Shergin's well), is located in the center of the Yakutsk and is now a national monument.

Today, Yakutsk is the home of a Research Institute which is sufficiently prestigious and sizable to host the Second International Permafrost Conference which was held there in July, 1973. Included was a tour, even though brief, of the Research Institute itself; the notes contained herein are based primarily on information gained during that tour and on conversations held later with some of the scientists who work there. Although in many instances details are lacking, the comments should encompass the general scope, capacity and potential of this Institute. For a long time it was considered as a branch of the Moscow Permafrost Institute but about twelve years ago became semi-independent when it was transferred to the Yakutian Branch of the Siberian Division of the USSR Academy of Sciences. At that time some 40 persons were employed; today about 300 work during the winter with the number increasing significantly during the summer months.

The Institute, located on the outskirts of Yakutsk, is about a fifteen minute drive from the center of the city. It spreads over a very large section of land and consists of more than 20 buildings, a birch forest and some open fields. Most of the structures are about 15 years old. However, there is a great amount of construction going on at the present time, the bulk of which is for housing. Apartments are rapidly replacing log houses not only in Yakutsk itself but also at the Institute. One such building is now functional, another is under

*Reprinted from *European Scientific Notes* 30 November 1973.

construction and a third is to be started next year. Each has 64 family units and all provide housing for the personnel of the Permafrost Research Institute.

Although there are many out buildings for various purposes, the main activity of the Institute is conducted in a large three-story structure that contains offices and laboratories. Many of the laboratories are small rooms equipped for very specific types of chemical, physical and biologic research. The Institute also maintains a tunnel in the permafrost which is entered by a door from the basement of the main building; it was dug about seven years ago, has several side caverns in which various research projects are being conducted. One of these caverns has been converted into a cold room wherein the temperature can be reduced to -40°C. Another is being used for testing the shear strength of various types of frozen ground. Some 15 m beneath ground level, the tunnel is about 4 m wide, 3 m high and 25 m long and has a constant temperature of -4°C. It lies in sediment that was deposited some 10 to 15 thousand years ago as dated by C-14 (Carbon-14 age dating) methods. In deed, one of the side rooms is a C-14 laboratory which was recently put into operation. Siberia has only one other C-14 laboratory which is at Magadan on the Sea of Okhotsk. Possibly the most interesting artifact in the tunnel is the remains of a mammoth which had been discovered on the Indigirka River two years before, a find to be noted in the current issue of the *Polar Record*.

The Director is Dr. P. I. Melnikov, a corresponding member of the USSR Academy of Sciences, who has been in Yakutsk for nearly 40 years. Below him is an Administrative Section which consists of a scientific secretary and three deputy directors followed by nine separate divisions, each with its own head and its own area of research, e.g., general geocryology, geochemistry, thermal amelioration, hydrology, the Quaternary, and electrical prospecting. In addition to the nine topical divisions, there are two permafrost research stations which operate out of the Institute. One is at Igarka, the other in the Tien Shan Mountains. The latter is primarily responsible for the study of permafrost under alpine conditions.

Basic research is emphasized, thus one many-faceted project is involved with the determination of the effect that various types of surface cover have on permafrost. Test plots include an open field, a forest area and a site stripped of its vegetal cover. All three sites have equipment which monitors conditions in the air, in the ground and at the interface between. This micrometeorological equipment measures and records incoming and outgoing radiation, wind, and humidity, among other parameters. In winter, information about snow is also collected. For example, snow temperatures are obtained with thermocouples of 5 cm intervals and the radiation of the snow cover is monitored. Most measurements are continuous and are transferred to a separate building with specially designed recorders. These are tied in closely with the Institute's computer operations.

Larch is the most common tree in the Tien Shan Mountains and the one that grows best on the silt and loams which are so abundant in Siberia (generally areas of sand support pine trees). On one such forest test plot the Institute has a tower which is 16 m tall and has a 5-m extension. This is high enough so that

measurements can be made to a height twice that of the forest itself. It is considered that information obtained from this tower system will be extremely important in connection with the future development and maintenance of Siberia because, except for the tundra areas of the north, it is nearly all covered with forest. The temperature of the ground in the forest is 2° to 3°C lower than in the open. Further, it has been found that in the Yakutsk area the active layer averages about 1.5 m under a forest cover, whereas in the open it averages about 1.8 m. Radiation measurements show that over meadows the albedo is about 17 to 18%, whereas in the forest it is only 10 to 11%. Additionally, it has been calculated, even though based upon only three years of records, that the forest has a radiation balance some 1.5 times that of the meadow area and that the radiation getting to the forest floor penetrates some 60% lower than that reaching the meadow surface.

The tower, constructed only three years ago, is already providing information which is not only interesting but may contribute significantly to a better understanding of energy budgets in permafrost environments in the near future. Accompanying chemical measurements are not yet being made at Yakutsk, although it is planned to initiate such measurements soon.

In conclusion it must be stated that the Permafrost Research Institute is both unique and impressive. It is impressive because of its size and potential and the number and attitude of its staff. As many scientists and assistants work at this one center as are employed in similar research in all Canada and the United States. It is unique because of its location and because the entrance is guarded by a large portrait of Lenin and a life-sized mammoth which spouts water through its trunk. (H. J. Walker, Professor of Geography, Louisiana State University, Baton Rouge, LA.)

NRL Sheds New Light On Sea Floor Spreading

Ocean scientists at the Naval Research Laboratory (NRL) have obtained more than 5000 photographs of the sea floor inside the median Rift Valley of the Mid-Atlantic Ridge with NRL's LIght BEhind Camera (LIBEC) system.

The LIBEC concept permits photographs of the deep ocean bottom to be taken at greater ranges than heretofore possible. This is achieved by separating the camera from the zone of intense backscatter near the light source while directing most of the light energy towards the outer edges of the target area.

LIBEC is deployed from NRL's research vessel MIZAR through the ship's center well, and towed by means of a cable-telemetry system, which has enhanced the Navy's deep search capability.

Although the majority of the photos corroborate previous information that the Rift Valley is floored with pillow lava, others revealed a wealth of additional detail. Many steep scarps and fissures were seen, some of which were correlated over distances up to two miles. Further studies are planned to determine if these structures are related to volcanic or tectonic processes.

Steep rock surfaces were found to harbor a variety of sessile animals, while deposit feeders were noted in zones where pelagic sediments had accumulated.

More active creatures were present in a number of exposures, and at least two photographs were taken of the rare cirrate octopod (umbrella octopus).

During the Rift Valley tests, temperature was monitored continuously and water samples were collected along each photographic run. Measurements on certain micro-constituents in the water are planned by NRL to determine recent volcanic activity.

The mission was completed in cooperation with the Woods Hole Oceanographic Institution and under the auspices of the National Science Foundation, as part of the French-American Mid-Ocean Undersea Study (FAMOUS). FAMOUS is the most comprehensive study of the Mid-Atlantic Ridge ever attempted. The Naval Intelligence Support Center has been tasked with assembling the NRL photographs into a photo-mosaic map.

The ridge is part of an undersea mountain range that is the most extensive surface feature on earth; a great suture where the continents joined 200 million years ago.

Scientists say it is now generally accepted that in the center of this suture, in the median Rift Valley, new crustal material periodically wells up as molten rock to congeal along the edges of massive plates. The plates spread outward from the ridge transporting sea floor and adjacent continents at a currently-measured average rate of 1.3 centimeters per year.

Continental drift is now variously called plate tectonics, sea floor spreading and the new global tectonics.

NRL is an integral part of the FAMOUS team, which pools the talents of many prominent oceanographic institutions and laboratories around the world to learn more about this fascinating process which slowly changes the face of man's planet.

Logistics Research Conference

The Office of Naval Research and the George Washington University, with the cooperation of the Air Force Office of Scientific Research and the Army Research Office, announce a Logistics Research Conference to be held at the George Washington University, Washington, D.C., on 8-10 May 1974. The main objectives of the Conference are to survey major developments and difficulties in government, industrial and military logistics research and applications since World War II, and to assess outstanding current problems and promising new research techniques.

Areas of research activity have been categorized, as follows: 1) applications of mathematical programming; 2) applied case studies; 3) design of systems; 4) inventory systems; 5) data collection, representation, and analysis; 6) measurement of performance; 7) probabilistic methods; 8) production and procurement; 9) reliability, maintainability, and availability; 10) simulation; 11) statistical methods; and 12) transportation and scheduling.

Contributed papers are welcome. Abstracts and inquiries may be addressed to Ms. Henrietta Jones, Department of Operations Research, The George Washington University, Washington, DC 20006. (Phone: 202/676-7504) Further

information may also be obtained from Professors Anthony V. Fiacco (202/676-7511), W. H. Marlow (202/676-7503), or Henry Solomon (202/676-7521) at the University, or from Mr. Marvin Denicoff (202/692-4304) at the Office of Naval Research.

Marine Fog Studies Aboard The Hayes

Naval Research Laboratory (NRL) scientists are planning an intensive investigation of marine fog formation in the area of the Galapagos Islands aboard the Laboratory's catamaran research vessel, USNS HAYES, in February.

Chemists, biologists, oceanographers and physicists of NRL's Ocean Sciences Division, as well as other scientists from Navy, university and contractor laboratories, will conduct multi-disciplinary experiments in an attempt to resolve some of the important questions on the formation and persistence of marine fogs.

The expedition will be led by Dr. Lothar H. Ruhnke, Head of the NRL Division's Atmospheric Physics Branch.

The Galapagos, best known through Charles Darwin's 19th century research on evolution, straddle the equator about 600 miles west of the Equadorian coast. This area is marked by a relatively frequent recurrence of marine fogs, that is, those not influenced by huge land masses or coastal regions.

According to Dr. Ruhnke, strong horizontal temperature gradients in the ocean surface layer may be responsible for marine fog formation in this area. The high frequency of marine fog formation will provide the scientists with opportunities to measure, in detail, various phenomena associated with fog formation and dissipation.

Environmental factors to be measured include wind velocities, sea and air temperatures, fog visibility and duration, air mass identification, aerosol and water chemistry, droplet size, atmospheric electrical charge, and identification of micro-organisms such as bacteria which may be associated with fog droplet nuclei and aerosols.

The HAYES is equipped with a sophisticated digital data collection computer system which can provide solutions for numerical fog models from realtime data.

The results should provide insights and better understanding of fog generation and duration which are so important for the safe operation of the Navy and commercial fleets.

NRL Scientist Innovates Synthetic Aperture Radar for Oceanography

An oceanographer in the Naval Research Laboratory's (NRL's) Radar Division, has successfully tested the application of synthetic aperture radar (SAR) for detecting and mapping ocean current boundaries.

Although airborne radar systems have been used experimentally as well as operationally in remote sensing oceanography programs, none has involved the use of SAR or large scale ocean current systems, until now.

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In the application devised by Lionel Moskowitz, SAR imagery is obtained on moving film by photographing the face of a cathode ray tube on which the phase history of a target is displayed as an intensity modulation. The speed at which the film is advanced is proportional to the aircraft speed. The signal film is analyzed on an optical bench where a coherent laser beam is passed through the film. Phase history of each target is focused to a point and recorded on another film strip. The result of this process is a photographic-like image of the surface illuminated by the radar beam.

At a recent conference on remote sensing in oceanography, Moskowitz explained that through the SAR imagery obtained off the US east coast, he was able to discern, position and map the north wall of the Gulf Stream.

Sea surface temperature data confirmed the radar observations, and the radar data confirmed a proposed model of the general circulation pattern off the east coast. The position of the Gulf Stream relative to the US east coast plays an important role in weather modification, shipping and fishing.

The use of airborne SAR techniques offers a very high resolution capability for tracking major current systems and eddies, such as the meandering Gulf Stream.

NAVAL RESEARCH REVIEWS publishes highlights of research conducted by Navy laboratories and contractors and describes important Naval experimental facilities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code 109, Office of Naval Research, Arlington, Va. 22217. Requests for subscriptions should be directed to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Subscription price: $4.50 per year in the U.S. and Canada; $5.65 per year, foreign; $0.45 per individual copy. The issuance of this periodical approved in accordance with Dept. of the Navy publications and printing regulations.

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Cover Caption

With sail removed, ALVIN, is transferred to a flat-bed truck which will carry her into the Ocean Environment Simulation Facility for certification dives.

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